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The Miami Conservancy Bulletin

MAY 1920

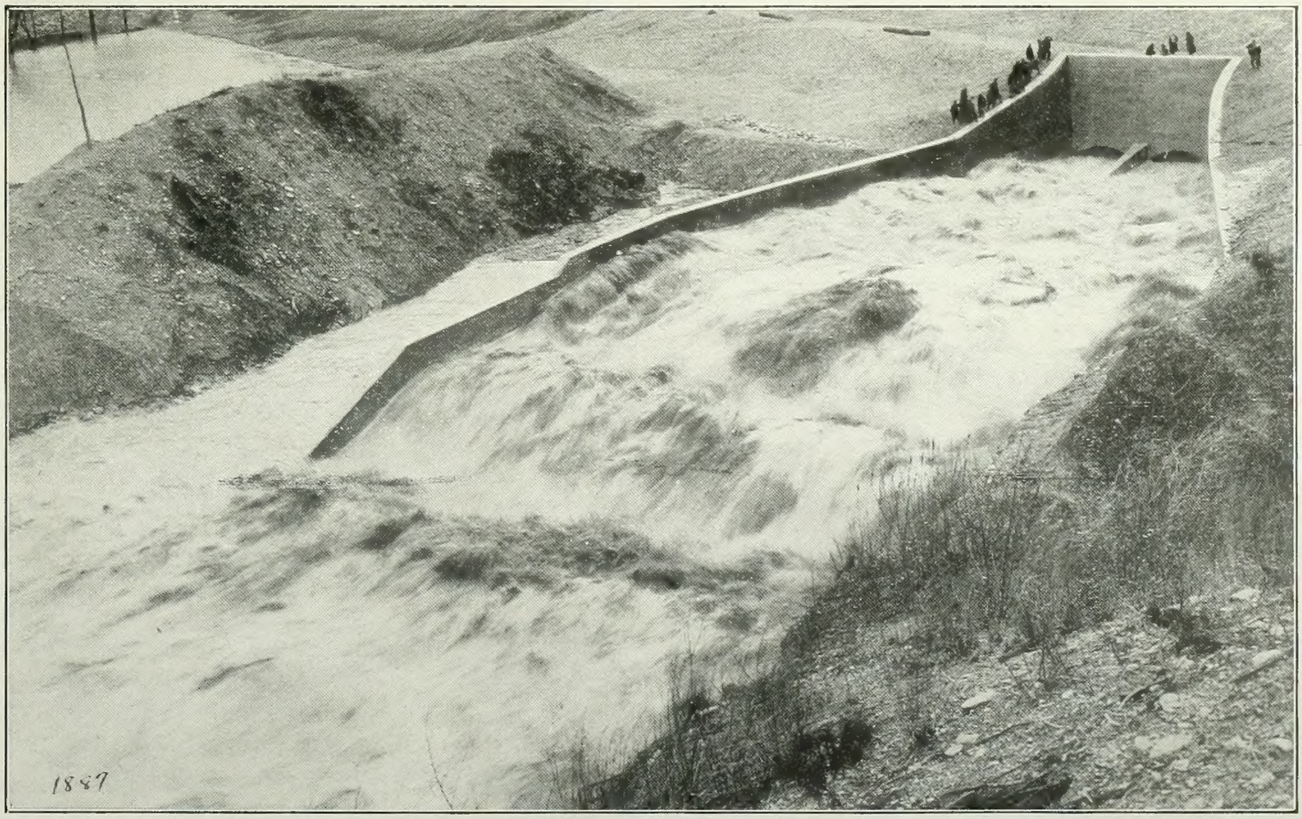

FIG. 123—HYDRAULIC JUMP AT GERMANTOWN DAM OUTLET, APRIL 20, 1920.

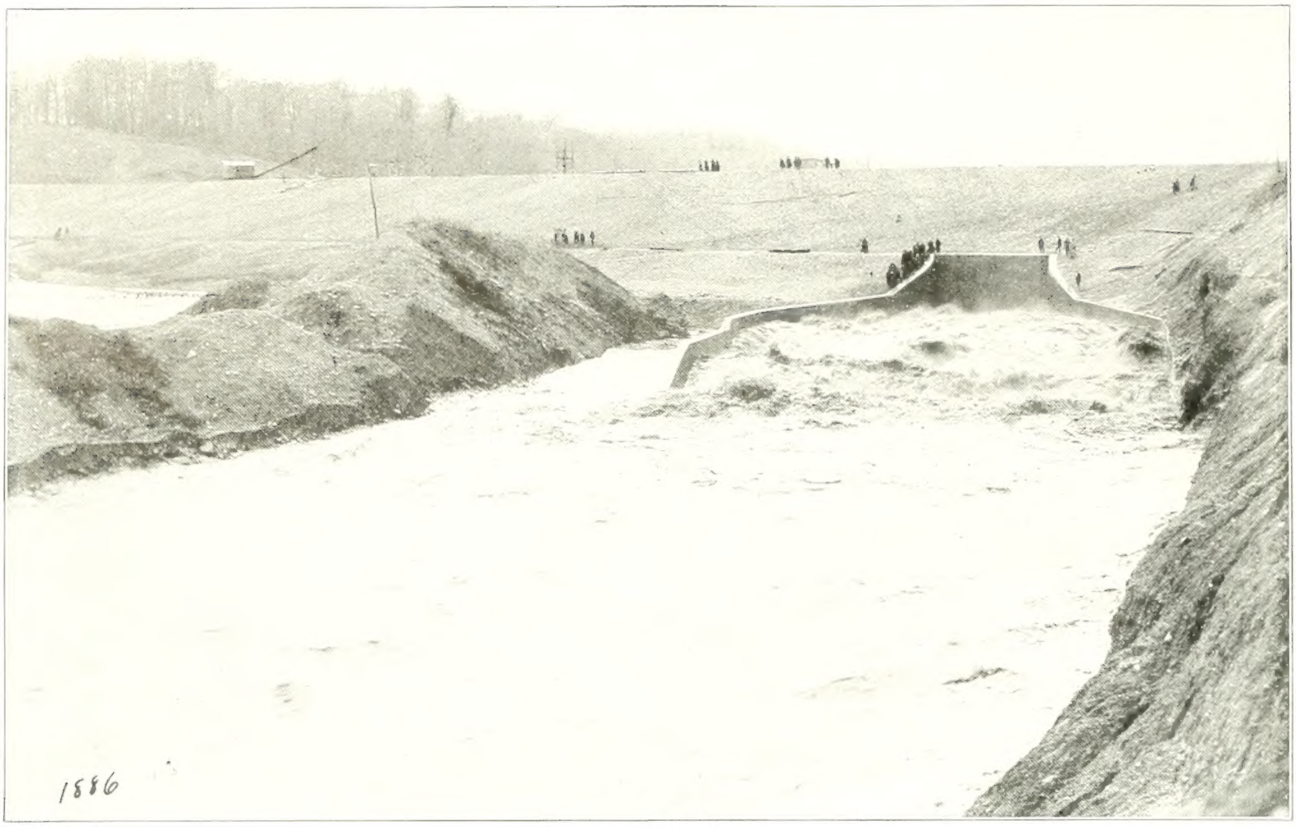

FIG. 124—HYDRAULIC JUMP AT GERMANTOWN DAM OUTLET, APRIL 20, 1920.

The dam crest is seen above the outlet, extending from hill to hill, blocking the valley. The flood water is coming through the outlet. In Fig. 123, the water at the highest point in the outlet channel was about six feet above its level at the conduit mouths. See also editorial, page 148.

FIG. 125—THE FLOOD AT TAYLORSVILLE, APRIL 21, 1920.

No injury was done here. The old M. & E. canal bridge abutments, seen just beyond the trestle, stood through the 1913 flood, all of which flowed between them, the abutments and the canal embankment, seen also at the left over the trestle, being unsubmerged by the flood. See page 152.

THE
MIAMI CONSERVANCY BULLETIN

PUBLISHED BY THE MIAMI CONSERVANCY DISTRICT
DAYTON, OHIO

Volume 2 May 1920 Number 10

Index

Subscription to the Bulletin is 50 cents per year. At news stands 5 cents per copy. Business letters should be sent to Office Engineer, Miami Conservancy District, Dayton, Ohio. Matter for publication should be sent to G. L. Teeple, Miami Conservancy District, Dayton, Ohio.

The Flood of April 19-21

Interesting and significant aspects of the flood of April 19-21 are treated elsewhere in this issue. One that may well receive further emphasis is the needless and acute state of alarm into which many people of Dayton were thrown during the higher stages of the river. Such fears are quite natural in Dayton. Whoever went through the experience of 1913, when the river rose beyond earlier flood levels, cannot escape the influence. It sunk into many minds an indefinite and fearsome impression of a flood as an incalculable thing, running out of the bounds of all ordinary law and prediction. They think of it as people in parts of Italy think of the earthquake and the volcanic eruption.

The impression needs vigorous combatting. A flood in Dayton is not incalculable. It follows definite and well-known laws. Given rainfall on any part of the Miami Valley watershed, and its effect on the river can be foretold with surprising accuracy. The Conservancy engineers spent five years in studying that watershed, the rainfall which reaches it, and the methods to meet the emergencies of floods the rainfall brings. Thirty-five river and rainfall stations are spotted over the watershed, where sentinels are set to watch and report. Reports in emergency come by telephone to the Conservancy Office. The quantity of rainfall is known. Given this quantity, the amount which will reach the river is known, very closely. And the speed with which the water will run down the valley is also known. Thus the time of arrival of a flood crest can be predicted. River levels are known all up and down the valley. The District Forecaster sits in his office with his finger on the pulse of the river, and the pulse of the river has this advantage over the pulse of a human patient—that the pulse of the river beats so slowly—travelling downstream—that the Dayton pulse beat can be predicted many hours ahead, and alarm sent out if need for alarm arises. Millions of dollars and years of time have been spent on the Miami Valley project. It is safe to say that no such study of storm rainfall and its effect on a given river has ever before been made. And the study has this immediate value here and now—that the people of Dayton can sit safe in the knowledge that they will be warned when it is time to move out.

What is said above is said without qualification. Scarcely less strong is the point made on page 150, regarding the needlessness for alarm at all during the spring and summer months. Floods are not lawless. All storms which can bring dangerous floods to Dayton sweep across the country in broad orbits, following well known if somewhat variable paths. The effect of the season is also well known, and in the Miami Valley is one of the most marked characteristics brought out by the study of the Conservancy engineers. Rain cannot soak into frozen ground. Practically all that falls runs into the river like rain off a roof. In spring and summer a large percentage soaks in, "drinking a flood up" before it can form. When also the records of the valley are searched, after considering the above, and no record can be found in all its history of a spring or summer flood which would rise within seven feet of the present Dayton levee tops, it will be realized how needless were the fears of those Dayton people who in panic packed their goods and moved upstairs or moved out.

The Hydraulic Jump

The flood of April 16-21, 1920, gave the first opportunity to observe in action the operation of the hydraulic jump, as utilized and adapted in the outlet

works of the District dams. The operation at Germantown is shown in Figs. 123 and 124; at Lockington in Figs. 135 and 136. At Huffman and Englewood the outlet works are completed, but the "jump" did not come into action, at Huffman because Mad River is still flowing through the diversion channel instead of the regular dam outlet, and at Englewood because, the river channel being still open, the flood flow through the conduits did not reach a stage high enough to produce the characteristic action. At Taylorsville the outlet works are not yet built.

Technically the hydraulic jump represents the solution of one of the most formidable problems which the engineers of the District were called upon to face—the quenching of the destructive energies of the swiftly moving masses of water as they come pouring through the dam outlets in seasons of flood. Mountain torrents move rock masses which weigh thousands of pounds. Eddystone lighthouse, built of rock, on rock, was repeatedly destroyed by the battering action of swiftly moving waves. Flood water, at maximum stage for which the dams are built, will pour through the Englewood outlet at a speed of fifty to sixty feet per second—more than 30 miles per hour—hundreds of tons coming through every second. Let loose on the valley below, without restraint, these swiftly moving masses of water would tear up the river bed in a way which might undermine the dam itself. Some device was absolutely necessary to check and destroy the power of the flood water to do such mischief. An adaptation of the hydraulic jump was the solution.

The solution of the problem by this means is unique, the jump, while seen in action at the foot of the apron of every overfall dam, never before having been applied to water issuing from conduits under high heads. It was the result of extended mathematical investigation, and of an exhaustive set of experiments on a working model, corroborating the theoretical study. The hydraulic jump was shown to follow a law as exact and unvarying as that of gravitation, and furnishing as stable a foundation for engineering design. Mechanically the solution was as simple as it was unique. It was due principally to Professor S. M. Woodward, Consulting Engineer of the District, with the assistance of R. M. Riegel, now the District's Designing Engineer, and of J. C. Beebe.

The final design, as built at Lockington, was shown in Figs. 1, 5, 7 and 14, of the Bulletin for August, 1914. It consists essentially of a broad concrete chamber, at the foot of a widening concrete stairway which leads down from the outlet mouths of the conduits, the water flowing down the stairway into the chamber and on over a wall or weir into the river channel downstream. The top of this wall is only a foot below the level of the conduit floor, so that the chamber is always full of flowing water, whether in flood or not.

In full action under high flood, after completion, the water will issue from the conduits in a solid stream and descend the stairway in a widening and thinning and fairly smooth-surfaced sheet, till it plunges into the mass of water which occupies the pool chamber and stairway channel below, forcing this mass part way down the slope ahead of it, and piling the pool water up in a sloping wave front, beyond which the water flows away almost level with the wave top. The whole mass of water in the pool chamber is lifted in level by the tremendous impact of the descending water, so that the upper portion, next the wave, flows back upstream down the slope of the wave front, in a mass of boiling foam, just as it flows down the front of a shoreward moving breaker on a sea beach. The energy of the descending sheet of water indeed penetrates the entire mass of water in the pool chamber, throwing it into violent agitation, and causing it to lather and foam and eddy in every part of the pool. In these myriad boils and lathering eddies the energy of the water is scattered and dissipated in innumerable collisions between its particles, and its speed as a mass downstream checked. It is as if a charging army were suddenly thrown into complete disorganization, and every man were to start charging in a different direction, at cross purposes with his neighbor.

A word as to the name—hydraulic jump. From one point of view it is apt. The water, descending smoothly the slope from the conduit outlet, seems to take a sudden "jump" and break into foam. But really the name is misleading. The descending water does not "jump." It plunges into the base of the stationary wave, and forces up the water further downstream in the pool chamber. The "jump" is only in seeming. The water where it seems to occur is really flowing down the slope of the wave front, upstream.

In connection with the above, the reader should be warned that Figs. 123 and 124 do not show a true hydraulic jump action, as the conduit floors at Germantown are at present about 12 feet below their true level, in order to increase the conduit capacity while the dam embankment is under construction. This throws the action as described above, quite out of normal, through its adaptation to the temporary circumstances. At Lockington (Figs. 135 and 136) the conduit floors are at their final level (although the sides and arches are not completed), and the true action develops.

Englewood Pumping Record

On April 27 the night crew on the hydraulic fill at Englewood broke its record. In a running time of 9 hours 19 minutes, one of the dredge pumps pumped into the dam a total of 312 cars of earth, equal to 2808 cubic yards. This is at a rate of 33½ cars, or 301 cubic yards, per hour. Last year's record for a single pump was 200 cars during one shift. The pumps are 15-inch pumps, and the material goes into the section of the dam east of the river.

Since then the work on this section has been stopped until the river section can be brought up to a corresponding level. Work on the river section is begun and the above record was in turn broken by one of the pumps on this section, which pumped 435 cars in 8 hours 6 minutes, or at the rate of 395 cubic yards per hour, working against a static head of about 21 feet. It will require nearly a million cubic yards to bring the river section up to the level of that east of the river, and it will take until about October to pump it. Both sets of pumps, four in all, will then take up the task together, the two sections being thrown into one, with a set of pumps serving each half.

The Flood of April 19-22

Effect of Conservancy Work on the Flood

Flood control in the Miami Valley project is effected by two means—by the operation of the dams, and by improving the river channels. At Dayton the principal effect, as between these two, is that of the dams, especially the three immediately above it, the Taylorsville dam on the Miami, the Englewood dam on Stillwater River, and the Huffman dam on Mad River. As the river channel at these points is still necessarily wide open, as a protection to the dam structure itself during construction, the flood at Dayton was reduced in height very little. Moreover, the channel improvement through Dayton is largely levee building, there being comparatively little effect due to widening and deepening the channel itself; which means that what is being done in Dayton is little felt till the higher flood stages are reached—stages higher than the late flood.

An interesting detail of this was the effect on the river stage just above Island Park dam, a low overfall structure at the junction of the Miami and Stillwater Rivers, near the north city limit. Mad River comes in about seven-eighths of a mile further down, and a little above Main Street. The Main Street gage gave a maximum flood height 1.4 feet higher than in 1916. The Island Park gage showed a reading 0.8 feet lower than in 1916. Naturally people who knew this thought the Conservancy work between the two points had effected a lowering of the river by 2.2 feet (the sum of 1.4 and 0.8). It was a natural inference, but in fact only about five inches of the difference can be so credited. The Stillwater and the Miami, coming together at Island Park, had a combined flood flow in 1920 which was 2300 cubic feet per second less than in 1916, while Mad River, coming in below, had a flood flow which was 10,700 cubic feet per second greater. What the Island Park gage showed was the effect of the lessened flood flow in 1920 of the two streams coming together right at that point. The increased flow of Mad River came into the Miami too far below Island Park to effect the gage there. Main Street gage, however, just below the mouth of the Mad, felt the full effect of the Mad River increase, and ran up to an increase above 1916 of 1.4 feet, in spite of lessened contribution of the two other streams.

At Hamilton, about 40 miles below Dayton, valley storage above the city, in the long course of the river, would act to a very considerable degree as a retarding basin, even with no dams built. Here, therefore, the channel itself must play a larger share in the work of protection, and for this reason, and also because the work there is largely a job of channel deepening and widening, and so gets in its effect even at lower stages, the work already done at Hamilton effected a very considerable lowering of the flood height, amounting to a little over two feet.

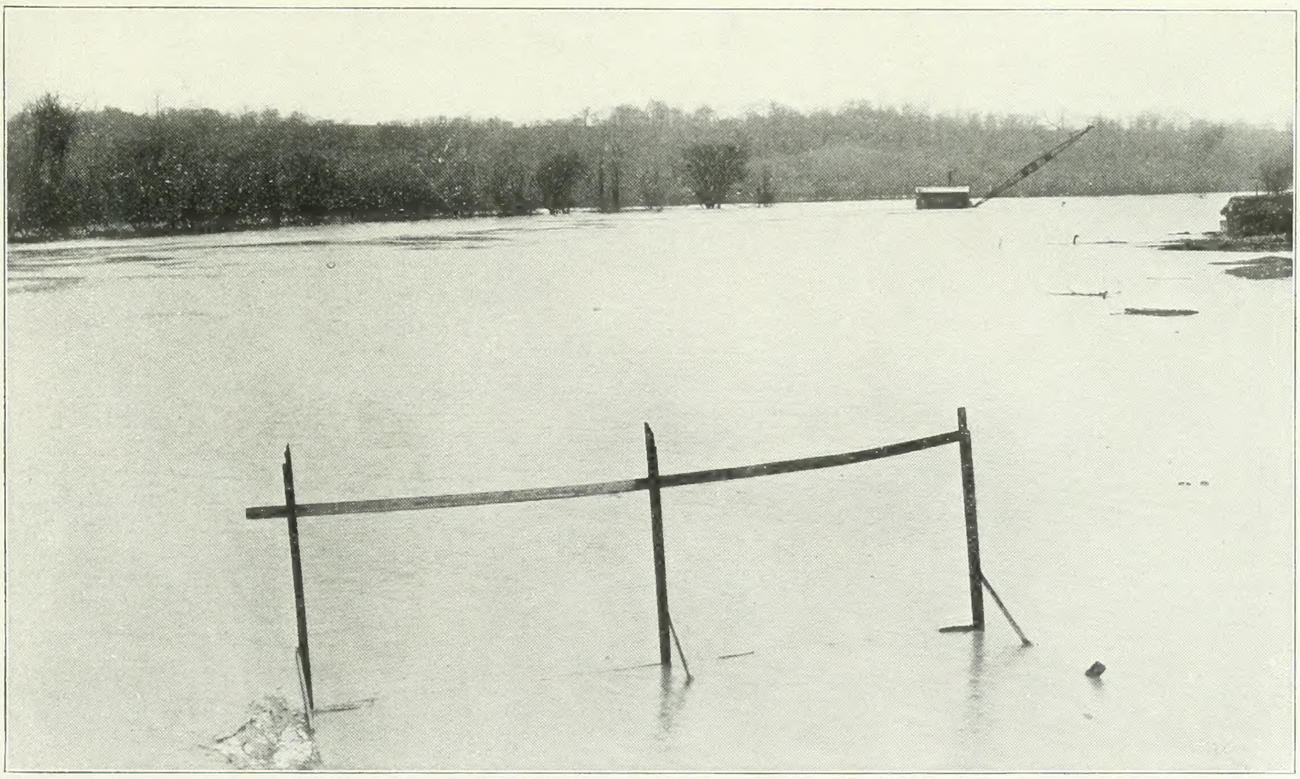

FIG. 126—DRAGLINE EXCAVATOR "AFLOAT" ON THE FLOOD, APRIL 20, 1920.

This machine was engaged in digging earth for the dam embankment, on the valley bottom above the Germantown dam. The water rose into the house, but did no material damage. The electric motors, after their bath, were "rubbed down" and dried out by running a low voltage current through the coils. Flood crest behind the dam was 26 feet above low water, flooding about 250 acres in the valley above, the flats being flooded for about two miles upstream.

The Germantown dam, the only one as yet to effect full closure of its valley, and which is already up to a height to take without injury a flood equal to 1913, did the full work expected of it. The water behind the dam rose about 26 feet; below it about 9 feet; creating thus a difference of level of about 17 feet, and storing some 82,700,00 cubic feet of water in the retarding basin, reducing thus the flood flow by 3,000 cubic feet per second. This reduced the Twin Creek flood crest by about 9 to 12 inches, below the dam. The main interest at Germantown was in the operation of the conduit outlets (see Figs. 123 and 124), which was entirely satisfactory. (See also page 148.)

Needless Alarm Over the Flood

The maximum stage at Main Street, 16.2 feet above low water, was nearly 3 feet higher than last year, and 1.4 feet higher than in 1916. In Dayton naturally, with a possibility of more rain, this created considerable alarm, the more so that in North Dayton (a part of the city), people on Tuesday had to be taken out of some of the houses, the lower stories being flooded. This fear was heightened by the fact that more rain was coming at the time, continuing steadily all the forenoon, and followed by heavy showers in the night. Many moved into the second story; some even moved out entirely. Telephone inquiries came into the Conservancy office by hundreds. With conditions looking their worst, in the middle of the trouble at midnight Tuesday the telephone service—through no fault, it should be noted, of the Conservancy staff—broke down for several hours, creating still more alarm, naturally not unmixed with anger. The District Forecaster, Ivan E. Houk, was compelled to go to the central telephone office to get in touch with the rain and river reports, coming in from the various observers in the Valley. Acknowledgments should be made in this connection to the electrical staff of the Delco Light Co., who came to the rescue of the disordered telephone service, and in a few hours had it once more in operation.

The alarm mentioned was natural, yet it needs to be emphasized that there was very little ground for it. It should be remembered that the chances for serious flood, in Dayton, after the month of March, are exceedingly remote. The season for such floods is in January, February and March. There is no record of a storm in the 54 years last past, in the spring and summer months, which would have reached within 7 feet of the top of the present Dayton levees. In fact, as far as is known, the 54 years can be extended back through the entire history of the town. No flood in the 54 years, during those months, came anywhere near the present levee height. The nearest fell nearly 7 feet short; all the rest big enough to be worth recording, fell from 7 to 12 feet short.

As to the flooded houses in an outlying section of North Dayton, it only meant that Mad River was up out of its banks. The land is low land, of little value, and for which no protection levees have been planned or built, for the reason that protection would cost more than it would come to. It was a case of annoyance only, no real danger. The same may be said of the flooded cellars and basements in some of the lower parts of the city. In times of high water the storm sewer outlets, where they empty into the river, are shut by gates, and the local storm water which falls subsequently, backs up on the lower ground, except where removed by the city's sewer pumping stations. There is never enough of this to be dangerous. The flooded cellars and basements are in reality the sign that the city officials are on the job, and have shut the gates through which the real enemy might enter. The eliminating of such storm water accumulations is entirely a pumping problem.

Such facts ought to give reassurance. They ought to quiet alarm at such times. Even in the danger period, from January to March, great floods are rare. In the spring and summer months, in the records of Dayton, they are unknown. It may be said, of course, that "you never can tell." Well, of course you can't, absolutely. The sky may fall or the sun collapse. But in the face of the known facts, serious alarm over floods in Dayton during the spring and summer months, must remind one of the little boy who was afraid to go into the woods, as

FIG. 127—DAYTON DRAGLINE, APRIL 20, 1920

he told his mother, "because a tree might fall on him."

For even floods follow a law. They are high in winter because the ground is frozen, and whatever rain falls runs off into the rivers; and they drop to harmless proportions in spring and summer because the ground is like a sponge and can in large part soak the rain up and hold it for the growing crops. Common sense and the records combine to tell the same story.

The Effect of the Flood on the Conservancy Work and Equipment

While the District Forecaster's office was keeping in close touch with weather and river conditions, and issuing its Bulletins, those in charge of the Conservancy construction work were active in taking the necessary steps to guard the machinery and equipment from flood damage, as well as the work itself. In certain cases little could be done. A dragline excavator out in the middle of a broad valley bottom (as at Huffman—see Fig. 130), loading cars with earth for the dam, is largely at the mercy of the flood. To travel across the valley bottom and climb the higher ground consumes too much money and time to make it practicable. The chances of being caught in the act of escape are too great. And the bigger and more expensive the machine, the less the chance. A small machine on "caterpillar" traction can get away. (As witness the machine at Herman Avenue, which climbed the levee to higher ground). But a big machine, traveling laboriously on its "mats" and rollers, pulling ahead its hundred and forty tons "hand-over-hand" by its bucket and cable, faces a totally different job. One of the still bigger "drags," out in the middle of the Miami River, perched on an island which it has dug and built for itself out of river gravel, and compelled to roll its own two hundred tons, and carry its island with it, bucket by bucket, as it rolls (see Figs. 127 and 128), faces a still more insuperable task. Such big machines are simply "up against it." Caught in a flood, they pretty much have to take it as it comes. The electric motors can be hoisted up a few feet, to a precarious safety, but that is about all. Thus a dragline runner, on such a job, never boasts that he can carry on "in spite of h-ll and high water." He knows better. Come rain enough, he knows that, barring a boat, he will be marooned in his little "hen coop," like Robinson Crusoe on his island. The draglines in the various pictures in this issue, tell their own tale better than words can.

A few particulars from the various jobs may be interesting. The Stillwater valley saw the least rain of any of the main streams, and for this reason the flood at Englewood gave practically no trouble. A short and inexpensive washout on one of the borrow pit tracks was the main item of damage. The old river channel being still available as well as the dam conduits, which have been many months in use, there was no storage above the dam, and no retarding effect on the flood below. Work was stopped for half a day; some of it for a day and a half. There was no damage to equipment.

Germantown has already been referred to. The dredge pipe bridge across the inlet channel was swept away, unavoidably, and a few pipe lengths carried down stream. At the peak of the flood the north conduit ran completely full, the south one nearly so, and both functioned according to plan. (See page 148). The reservoir came into use for about two miles above the dam, the water rising into the dragline at the borrow pit, and wetting some of the machinery, but doing no damage of consequence.

At Taylorsville, there was no injury whatever, either to equipment or to the work itself. The river here is still running in its usual channel. The old Miami and Erie canal embankment extends from

This dragline excavator, a Class 175 Bucyrus machine, electrically driven, working weight about 200 tons, represents the greatest single item of injury wrought either to work or equipment by the flood. The unfortunate loss of two of the crew shortly before the flood, by drowning, was the probable ultimate cause of the accident to the machine itself, the remainder of the crew rightly giving first attention to the recovery of the lost bodies, with the result that the flood, when it came, found the machine in a position permitting it to be undermined.

The machinery was not materially damaged.

FIG. 128—THE DRAGLINE IN F G. 127, FOUR DAYS LATER.

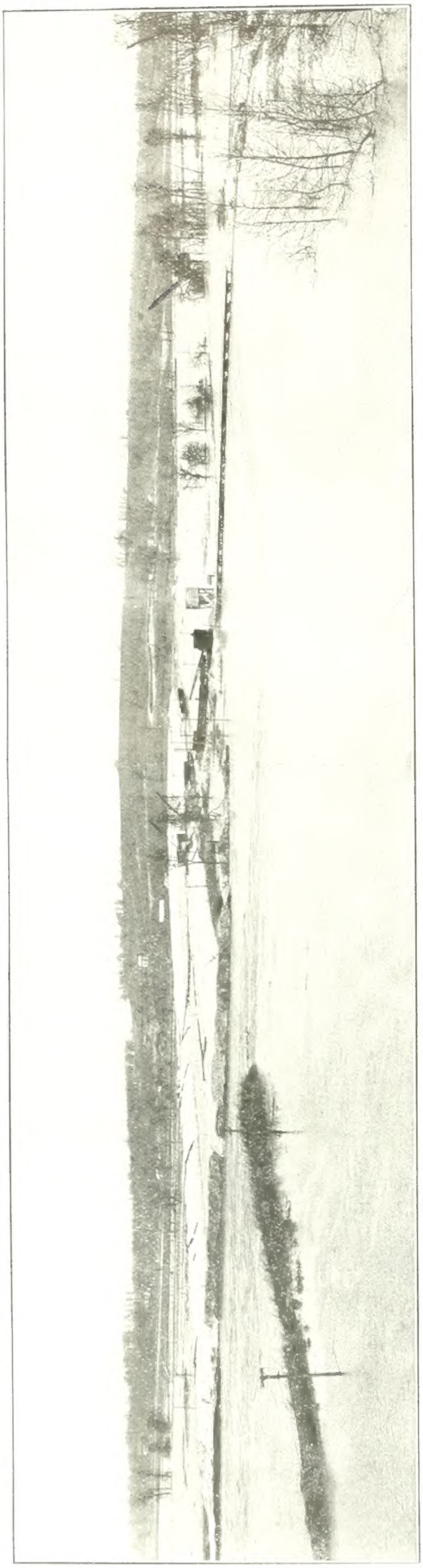

FIG. 129—VALLEY OF MAD RIVER AT HUFFMAN DAM, APRIL 21, 1920.

The section of the dam embankment under construction is seen at the left, only a little above the water. Mad River, running in its temporary diversion channel, flows past the near end of the dam embankment as seen, with the construction trestle crossing it nearly submerged. One bent of this trestle was washed out and the entire trestle would have gone, if the water had risen a foot higher. The dam embankment, partly blocking the valley, raised the water above it higher than in 1913. The difference in level above and below the dam was about four feet.

the west bank westward across the entire flat, with the built section of the dam embankment running parallel to it a short distance downstream. The canal embankment is high enough to extend above even such a flood as that of 1913 (see also Fig. 125), and thus sheltered the dam embankment from wash. The pump motors had been hoisted out of reach of the flood, and men patrolled the upper trestle clearing away flotsam and drift. The dragline at the gravel pit (see Fig. —) was submerged to the house floor, but came through without damage. The river rose to a level fifty feet above the bottom of the new outlet channel, where concreting is in progress, causing more than usual seepage through the intervening coffer dam due to the unusual pressure, but this was easily kept down by setting an additional pump at work. The concreting was held up three days. An interesting comparison is furnished by the fact that the flood, which was all forced between the M. and E. canal bridge abutments as in 1913 (see again Fig. 125), showed this time no drop in the water at all, as it came through the opening. In 1913 the flood at this point dropped five feet, furnishing the best measurement obtained by the Conservancy engineers of the flood flow.

General flood conditions at Lockington may be inferred from the informal report of the engineer in charge that "a few loads of earth were washed from a camp road, and a few potatoes in the camp garden uncovered." The pumps shut down for about six hours to free the crew for emergency work, but resumed while the flood was at its crest. The chief interest was in the operation of the hydraulic jump at the conduit outlet, the head through the opening being 10.1 feet, sufficient to bring the jump into action. The characteristic phenomenon appeared in accordance with the design. This being the first time that a jump has functioned at any of the dams, it was the object of much interest and satisfaction. For a fuller account of this, see pages 147 and 148.

The flood at Huffman was more severe than at any other dam, due to the higher rainfall on its watershed, and the damage wrought was greater accordingly. One bent of the main trestle across the new (temporary) Mad river channel was washed out. A foot more rise, and the entire trestle would have gone. There was minor damage to the Erie railway tracks and to one of the temporary highways across the borrow pit. Electric motors in the new pump house at the east end of the dam were flooded but suffered no damage except such as cleaning and drying would remedy. The same may be said of two of the smaller electric transformers. The dragline at the borrow pit was marooned, the water rising into the house, but doing no damage. The greatest single money loss was in the washing away of a pile of coal, totalling some 500 tons, about half of which could be salvaged. The total loss at the dam may be estimated at about $5,000. The dam embankment being up to a considerable height over the greater width of the valley, and the water practically all being forced through the opening in the new diversion channel, the water rose behind the dam about four feet, submerging about 250 acres and storing approximately 33,000,000 cubic feet of water. However, this storage taking place in about 24 hours, meant a saving in flood flow below the dam of only about 386 cubic feet per second. As

the total flood flow at the dam was 16,700 cubic feet per second, the effect on the river at Dayton was negligible (0.05 foot at Main Street bridge.)

Conditions at Dayton have already been referred to. Probably the greatest single loss anywhere along the river was due to the undermining of the big Class 175 Bucyrus dragline excavator. The accident might not have occurred, probably would not, but for the unfortunate loss of the lives of two of the dragline crew a few days before, by drowning. The search for the bodies of these men naturally took precedence over regular work on the part of the rest of the crew, with the result that the flood found the machine in a position which permitted the undermining of one corner of the gravel island on which it rested. (See also Figs. 127 and 128.)

At Troy there was a slight damage to one of the levees, and a delay to the work of a day or two. At Middletown the finished levee was scarcely affected, but a quantity of earth which had been moved by the dragline part way to its final position was swept away, this being the greatest item of single loss on any of the river work, unless perhaps to the big Dayton dragline machine. (See Figs. — and —). At Miamisburg the north levee west of the river was sandbagged to protect a factory, thus keeping the flood water down about 2½ feet. Heavy seepage, however, counteracted this work to some extent, the water apparently coming in through unlocated under drains. At Franklin the dragline machine lay in a much exposed position, and suffered some injury, not serious, to the house.

Rainfall and River Records During the Flood

The storm of April 15-20 brought a rise in the Great Miami at Dayton higher than has been recorded since the disaster of 1913, the maximum stage being 16.2 feet above mean low water. The next highest rise in the period was in February, 1916, when the stage was 14.8 feet. The 16.2 stage was really the result of two storms, the U. S. Weather Bureau charts showing two low pressure areas—storm centers—sweeping successively eastward across the country. Each storm was of about two days duration, and the interval between them also about two days, making a six-day storm period.

The first storm began on the night of Thursday-Friday, the 15th and 16th, bringing heavy showers in the upper Miami Valley, and lighter rains below. From Versailles to Bellefontaine these showers brought from one to two inches, causing the streams to begin to rise. Lighter showers continued at intervals on Friday, day and night, and into Saturday, all over the valley, this ending the storm. During this period the low pressure area passed from the western Mississippi Valley almost directly eastward to the region of Virginia, with its center passing a trifle south of the Miami Valley. It brought a total rainfall in the upper valley of from one to 2¾ inches, dropping to an inch at Dayton and fading out entirely at Hamilton.

A water level float at Main Street bridge in Dayton is connected electrically with a recording device in the Conservancy office, which makes a continuous chart of the stage of the river. This record (drawn on a sheet of paper with a pencil), shows no effect on the river until 4 p. m. on Friday afternoon, twelve hours or more after the rain began. It then rose sharply, six inches an hour till Saturday morning, and then more slowly, a total of 8 feet, ending at a stage of 9.6, the maximum effect of the first storm, at 7 p. m. Saturday. It then fell steadily until Monday at 4 p. m., to a stage of 6 feet.

Meanwhile the second storm had begun early Monday morning, with light showers all day and into the night, heavy showers on Tuesday morning, a steady rain all Tuesday afternoon, and heavy showers again that night, especially around Urbana and Springfield in the upper valley. This ended the storm, the weather clearing on Wednesday.

The total rainfall for both storms was from 4 to 6½ inches over the entire watershed. By contrast the 1916 storm brought 2.89 inches, distributed pretty continuously over five days. In 1913 the March flood fall amounted to 8.9 inches in six days.

The rains of the second storm being light at first, the Dayton gage shows no effect on the river there until 1 a. m. Tuesday, when a rise began, slow at first, but sharpening at 8 a. m. to a foot an hour for five hours, then more slowly again, rising to a crest of 11.8. This marked the effect of the quick "run-off" near Dayton. Then the upper valley water came down, pushing the gage up to its maximum for the storm—16.2, at 8 a. m. Wednesday.

It is interesting to note that for a short period between 4 and 5 a. m. Tuesday, the river at Dayton fell slightly, while all three streams, the Miami, the Stillwater, and the Mad (all meeting at Dayton), were rising only a short distance above, due to the arrival of the first of the upper valley run-off.

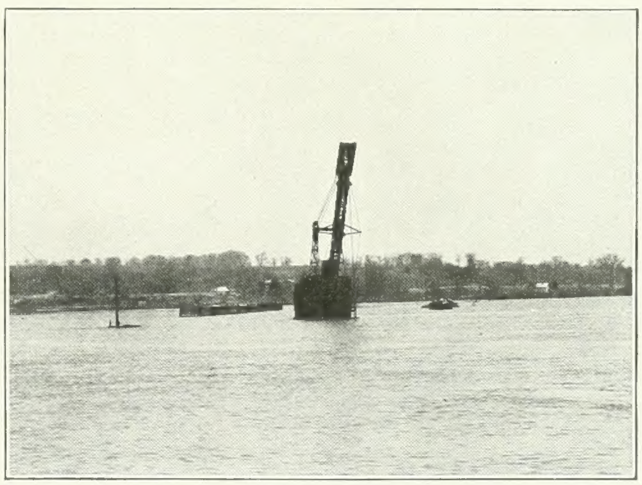

FIG. 130—HUFFMAN DRAGLINE IN TROUBLE

This is one of the 140 ton machines referred to on page 151. It was at work in the middle of Mad River Valley, here about a quarter of a mile wide, digging earth for the embankment. (It may be seen at the right in Fig. 129, through the trees). A dragline machine of this size and type (Class 24 Bucyrus) travels on rollers which run on timber mattresses or "mats," which the dragline bucket picks up behind and lays down in front. It then casts out its bucket in front by its cable (fly rod fashion) hooks the bucket teeth into the earth and pulls itself ahead. Such a machine can't very well run away from a flood.

March Progress on the Work

GERMANTOWN

Pumping was started on March 22, and is being carried forward in good fashion. The slopes of the dam have been built up to the second berm across the entire width of the valley to within 50 feet of the top. The total amount of material placed at the end of March was 442,000 cubic yards. This is approximately 56 percent of the total hydraulic embankment to be placed.

By lowering the grade in the open ditch leading from the borrow pit on the hill north of the pumping plant an increase was obtained in the amount of material sluiced. This adds greatly to the amount of core material obtainable.

Surfacing the upstream and downstream slopes of the dam has been started. A portion of the upstream slope is being surfaced with the oversized rock from the pumping plant. The top soil obtained by stripping the damsite is being spread over the downstream slope for the surface dressing.

The contract for the remainder of the excavation in the spillway has been let and it is expected this work will begin about the middle of April.

Arthur L. Pauls, Division Engineer.

April 17, 1920.

ENGLEWOOD

Hydraulic fill was resumed, after the winter shut-down, on March 18. To date this season about 100,000 cubic yards have been pumped, making a total of 1,102,000 cubic yards, or 31½ percent of the entire embankment. During the day shift, April 12, 460 cars of material were pumped. This figure breaks all similar records by a wide margin. The construction of Sump No. 3 and the railroad approaches is practically completed.

The river bottom has been unwatered and inspected, such cleaning as was necessary has been done and the lower portion of the tower erected for the pressure recording cells.

On March 19 one of the large electric draglines began excavating for the temporary spillway, west of the Stillwater River.

A strip of seedlings and cuttings of elm, willow, cottonwood, and osage orange has been planted across the bottom land, east of the river and a mile north of the dam, for the purpose of creating a drift screen to catch floating debris.

The excavation of the temporary spillway has necessitated moving the field shop and warehouse from its present location. New buildings for this purpose are being erected north of the dam, west of the river.

H. S. R. McCurdy, Division Engineer.

April 15, 1920.

LOCKINGTON

The hydraulicking was interrupted on April 5 by a failure at the aqueduct which carries the canal feeder over Plum Creek. As our supply of water for sluicing was thus cut off, prompt repair was necessary. A force of men under Superintendent Warburton's personal direction immediately started the work, with the result that in spite of adverse weather conditions the job was completed and water turned into the feeder a few hours less than one week from the accident. Pumping was resumed April 13. The aqueduct is now in better condition than it has been for some years. The old sides of the flume were rebuilt of new materials, sheet piling was driven at the four corners of the flume, and the banks repaired. One masonry wing wall was relaid.

The dredge pumps are working day and night shifts building that part of the dam lying west of the channel. The fill is now at elevation 913, thirty-seven feet above the old bed of Loramie Creek.

The steam dragline is working day and night shifts excavating the cut-off trench east of the channel. This work is about 90 percent completed.

Placing of the rock surfacing of both the upper and lower slopes of the dam is being continued.

A drift barrier has been started by planting a large number of seedlings above the dam.

On April 20, 5:30 p. m., Loramie Creek reached an 8.9 foot stage, higher than it has been since 1913. It delayed the hydraulicking only six hours, operations being resumed as soon as the water ceased rising. About 2000 second feet of water crossed the dam site and cut-off trench east of the outlet structure. Seven wagon loads of earth were washed from one of the camp roads, but otherwise no damage was done to the work.

Barton M. Jones, Division Engineer.

April 22, 1920.

TAYLORSVILLE

On March 30 the Lidgerwood dragline was shut down for repairs and a general overhauling, which will keep it out of service for about one month. The rock excavation in the inlet channel is practically finished and the balance of the earth to be excavated, about 100,000 cubic yards, will be cast up on the east bank and sluiced to the dredge pump.

The progress on the concrete last month was very good, the average for the month being about 200 cubic yards per day. The best average for one week was 250 cubic yards per day.

A track is being laid down the tow path of the canal in order to start storing gravel and sand for the main weir.

Some work has been done on the installation of the dredge pumps at the new location, but sluicing cannot be recommenced until the B. & O. R. R. tracks are removed to their new location. This will not be before about June 1.

O. N. Floyd, Division Engineer.

April 21, 1920.

HUFFMAN

The delivery of ballast gravel for the relocation of the railroads has been continued during the past month by the day shift, about 33,000 cubic yards having been put out to date. The dragline is moved ahead each evening and a sufficient area for the next day's work is stripped of clay and dirty gravel, down to the clean gravel, by the night shift. This top material is loaded onto dump car trains and taken to the dredge pump plant, whence it is pumped into the dam embankment.

Sluicing of material from the hillside at the north end of the dam, was started on April 9. This new plant is working very satisfactorily and the material found in the borrow pit is as good or better than had been expected. The sluice water is delivered to the giant at a pressure of 120 pounds per square inch, by two 10-inch pumps set at the foot of the hill. This water tears the material loose from the hillside and washes it through a 15-inch pipe flume directly into the dam.

C. C. Chambers, Division Engineer.

April 19, 1920.

DAYTON

Dragline D-15 is continuing channel excavation between Washington Street and Stewart Street. D-16 and D-8 are excavating for the unloading basin opposite the gravel plant. D-19 is grading the spoil bank between Herman Avenue and Webster Street.

Spring sowing of grass seed and dressing of levee slopes has begun.

About 2500 cubic yards of concrete has been placed in the South Robert Boulevard Wall, the work being now 56 per cent completed.

Sales of sand and gravel from the Sunrise Avenue plant have increased in volume during the past month. 8882 cubic yards of sand and gravel have been issued from the plant to date.

Price Brothers Company, working under contract, have started construction of concrete revetment above Herman Avenue bridge.

Channel excavation to date amounts to 801,000 cubic yards. The total pay quantity in spoil banks and levees is 492,000 cubic yards, including 60,000 cubic yards of levee embankment on Contract No. 41. In accomplishing this work the total yardage handled amounts to 1,325,300 cubic yards. These figures do not include excess excavation from the launching basin and scowing channels, amounting to 58,500 cubic yards.

C. A. Bock, Division Engineer.

April 17, 1920.

HAMILTON

The total yardage taken from the river channel to April 1 by the electric dragline, D-16-18, and the steam dragline, D-16-17, amounted to 1,200,000 cubic yards. The total for item 9 (channel excavation), was 660,900 cubic yards. The difference between the two figures represent mainly the earth excavated from the river bed to create a deep water channel, extending south of the city from Main Street bridge. The channel, by lowering the flow, helps protect the construction tracks from floods. These tracks are laid on the river bed, and carry the dump car trains which remove the earth of the regular channel excavation.

The electric dragline is still working on the last cut on the east side of the river between the Columbia Bridge and the R. R. bridge and is placing the material in the levee and the proposed boulevard east of the river.

The steam dragline has completed the excavation for the wall at the northwest corner of the Main Street bridge and will now drive the piling for this wall.

Price Bros.' concrete block plant has been completed and placed in operation. Price Bros. have also completed driving a 430-foot trestle north of the Columbia bridge, and will begin work on another, opposite the south spoil bank, in the near future.

The northeast wall at the Main Street bridge has been completed and concreting has been started at the southwest wall.

C. H. Eiffert, Division Engineer.

April 19, 1920.

LOWER RIVER WORK

Miamisburg: Jeffrey, Boorhem & Co. have not yet started their dragline machine. The narrow gauge tracks in the borrow pit have been put in shape to use. The camp has been moved to a point south of the Groendyke spur track and on the edge of the highway which parallels the B. & O. R R. A pipe culvert is being placed under Bear Creek Road just north of the levee.

Franklin: The material for the levee on the west side of the river between the C. N. R. R. and the suspension bridge is practically all in place: dressing and seeding, however, have not been completed. The dragline machine has moved under the suspension bridge and is throwing up material for the levee which extends northward 400 feet from the bridge. The existing wall and the elevation of the ground make it impossible for the machine to place all of the material directly into the levee, but it will throw the material up onto the bank and that which has to be moved a second time will be handled by teams. The machine will then move on up the river and commence building levee along the edge of River Road, about 500 feet north of Lake Avenue.

Middletown: Cole Bros. commenced work on the last day of March, having been shut down two months. They have one thousand feet of levee to build, extending southward from Seventh Street. They have made one throw and are now placing the material in its final location. This work will probably be finished in about three weeks.

F. G. Blackwell, Assistant Engineer.

April 17, 1920.

RAILWAY RELOCATION

Big Four and Erie— The Walsh Construction Company are now ballasting track for the Big Four and Erie. As the low elevation of the present location of the Erie interferes with the construction of the Huffman dam embankment, this road should properly be removed first. This, however, would necessitate operating the Erie across the present Big Four tracks, at Enon and Dayton, which is inadvisable.

The signal work at Fairfield is almost completed as far as this work can be done until the track is completely ballasted. The signal force will start work at Tates Point Interlocking Tower, where the B. & O. crosses the North Dayton cut-off, in a few days. An underpass is being constructed across the Big Four and Erie at Wood Park, near Focke's Point, the work being started on the 8th of April. The right-of-way fence is nearing completion. This work is being done by Funderberg Bros. of Osborn.

The Western Union Telegraph Company have resumed work on their pole line, which was delayed because of the lack of material.

Baltimore and Ohio—Roberts Bros. are finishing the ballasting and should complete their work about the middle of May. The District has a small force of men on this work digging ditches, etc.

The Baltimore and Ohio Railroad are nearly through with their own part of the work, south of Needmore Road. They expect to have it finished in about a month.

Ohio Electric—At the present time there is no construction work being done on the Ohio Electric. The pole line construction will be started in a very short time.

Albert Larsen, Division Engineer.

April 21, 1920.

RIVER AND WEATHER CONDITIONS

The rainfall in the Miami Valley during the month of March was about one-half inch less than normal. The greater part of the precipitation fell during three different storms: on the 4th and 5th, on the 11th and 12th, and on the 16th. Each of these storms caused a crest stage of about 8 feet at the Dayton gaging station. During the latter part of the month the river fell to comparatively low stages.

At the District's stations the total precipiation varied from 2.28 inches at the Lockington Dam to 4.18 inches at the Germantown Dam. At Dayton the total for the month amounted to 2.78 inches or 0.67 inches less than normal, thus increasing the accumulated deficiency since January 1st to 3.91 inches.

Observations taken by the U. S. Weather Bureau at Dayton show that the mean temperature for the month was 42.6 degrees or 2.2 degrees above normal; that there were 12 clear days, 9 partly cloudy days, 10 cloudy days and 12 days on which .01 inch or more of precipitation occurred; that the average wind velocity was 16.1 miles per hour, the prevailing direction being from the southwest; and that the maximum wind velocity for five minutes was 60 miles per hour from the south on the 28th.

Ivan E. Houk, District Forecaster.

May 4, 1920.

The Sewerage Systems at the Conservancy Camps

Sanitary Sewers Laid in Camp Streets, Draining to Sedimentation Tanks of a Modified Imhoff Pattern

To make clear the why and how of the simple sewerage systems adopted to serve the Conservancy camps, a very brief review of recent principles and practice of modern sanitary science may be useful.

Water and sewerage questions are of course closely inter-connected. Household, manufacturing and sewage wastes of a modern community corrupt the soil, poison the adjacent ponds and streams, infect them with disease germs, and by thus polluting the sources of water supply, endanger the health of the people and spread communicable diseases. Modern sanitary engineering sets sentinels and guards at both of these main gateways. Its aim is to purify the wastes and sewage, to filter and cleanse the water supply, and by keeping continual watch on both by means of regular tests and inspection, to maintain clean and healthy conditions for human beings to live under.

"To purify the wastes and sewage," however, is a somewhat elastic expression. The sanitary science of some years ago, over-zealous, showed a strong tendency to carry this process to great lengths; to insist that the discharge from a sewage disposal plant should be purified to the point where it would be harmless even if run directly into a city's water mains, and used for drinking purposes. Sewage disposal plants were indeed operated at a surprising efficiency in this regard. Enthusiastic sanitary engineers would show you a sewage "effluent" as clear as spring water, and prove their faith by drinking a glass of it before your eyes. Needless to say the visitor could seldom be induced to share in these

relations. He was not interested, perhaps, in honor out of which the "luck" had been taken.

Modern practice, however, is based on the belief that sewage purification carried to the length required is wasting money. As regard to the water supply, a dollar at the water works will go much farther than a dollar at the sewage plant. The main need of the latter is to prevent a nuisance, not to alter the city's water. Especially in small and less crowded communities like the Conservancy camps is this true.

Fresh sewage, carried through underground pipes of modern sewerage systems, is so highly diluted with water that it has little odor and is not particularly offensive. The organic substances which by their decomposition render it offensive do not constitute more than one part in 1200 or 1600 (in small rural communities), and not much more in most cities. They occur both as solids and in solution. It is the accumulation and decomposition of these at the sewer outlet, where it discharges, as it usually does, into some lake or stream, that produces the offense. The problem of sewage disposal is to break up these objectionable substances in the disposal plant, in such a way that the discharge from the plant is odorless and harmless. In most modern sewage plants this is accomplished by bacterial action.

The fact is interesting. Most of us think of bacilli or bacteria as dangerous "monsters," sources of disease and spreaders of pestilence. We picture them by millions and myriads, in the air and water, carrying death in an invisible cloud. We are told, of course, that like human beings they are both "good" and "bad," but we do not realize it. The sanitary engineer does. To him they are indispensable. They are his principal ally. They are the prize scavengers of the world, and as such he marshals them by millions and sets them at work.

For the suspended solids of the sewage, the principal bacterial work room is the "sludge chamber" in some form of sedimentation tank. The form used at the Conservancy camps consists of three rectangular concrete chambers side by side. See Figs. 131 and 132. The fresh liquid, bearing the solids, mostly in a finely divided state, flows through the two outside chambers "LL," Fig. 132, in a very slow stream, the chambers being very large in proportion to the pipes which bring the sewage. The bottom of these side chambers is sloping. The solids sink to the bottom and slide on down the slope through a wide slot into the central chamber "SS," where they collect and remain in a mass at the bottom. It is here that they are "attacked" by the bacteria.

The word "attack" is somewhat misleading, though often used. A bacterium is not an animal but a plant; it is truer to regard that each particle of suspended sludge in the chamber is as a separate field on which the bacteria grow, thriving as grass in a pasture. Unlike the grass, however, they consume a large part of the sustaining soil. But as fresh sludge is continually sliding down the sloping bottom of the sedimentation "hopper" into the sludge chamber, "fresh fields and pastures new" are continually supplied to the microscopic vegetation. Thus it is more fitting and correct to think of the sludge chamber not as a battle ground for "attack" but rather as a cultivated farm or garden, the object of

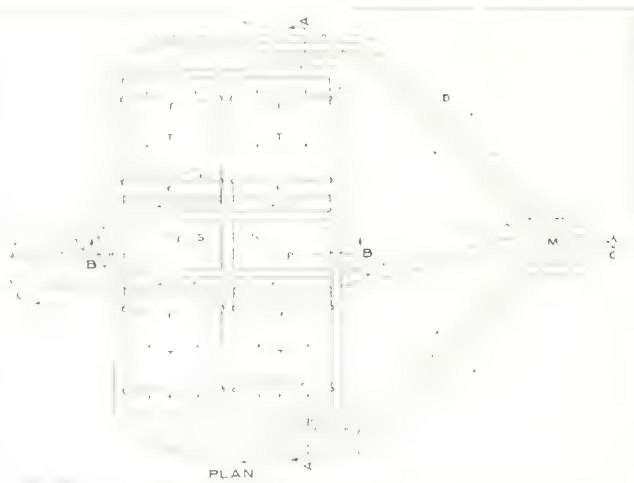

FIG. 131—SEDIMENTATION TANK PLAN

whose maintenance is to purify the garden soil.

An Imhoff sludge chamber, when first started in a new sewage plant, is said to "ripen," the required period being about four weeks. This means that it takes that time to "mobilize" the full quota of the bacterial army, or get the "garden" fully stocked with bacterial vegetation, and the purification process in full swing. The purified sludge accumulates at the bottom of the chamber, while the active bacterial growth is carried on in the upper layers, on the newly arriving sludge.

The sludge chamber being filled with liquid (practically all water, which enters with the first indraught of sewage), the ripened sludge is diluted with this water. The mixed ripe-sludge-and-water are drawn off periodically through pipes and valves, (pp. and vv. in Figs. 131 and 132) opening through the bottom of the sludge chamber, the water constituting 75 to 85 per cent of the mass. In many disposal plants this sludge is run onto a horizontal bed of sand, through which the water drains away, leaving the sludge, after several days' drying, in a condition resembling very porous or fibrous garden soil, and having no odor, or with an inoffensive odor resembling tar.

It is this inoffensiveness of the sludge discharge which constitutes one superiority of such a type of tank as that described (the Imhoff type), and which has rendered it the most generally accepted one in recent American practice. The sludge, after drying on the sand bed, can be removed and piled on waste land such as lies adjacent to most sewage disposal plants, where it lies inert, creating no nuisance whatever.

The liquid sewage in the side chambers of the Conservancy sedimentation tanks, "LL," after the removal of the solid particles as described, flows on, passing under the "scum boards" "ff" and then over the side wall of the trough "tt" into that trough, thence along the trough to the outlet pipe "oo." In the ordinary system, this discharges directly to a stream or lake, or to some form of bed for further treatment as conditions require.

The second outstanding characteristic of a tank of the Imhoff type, is that the liquid sewage, when discharged, is still "fresh," that is, has undergone practically no decomposition. This is brought about by the practically complete separa-

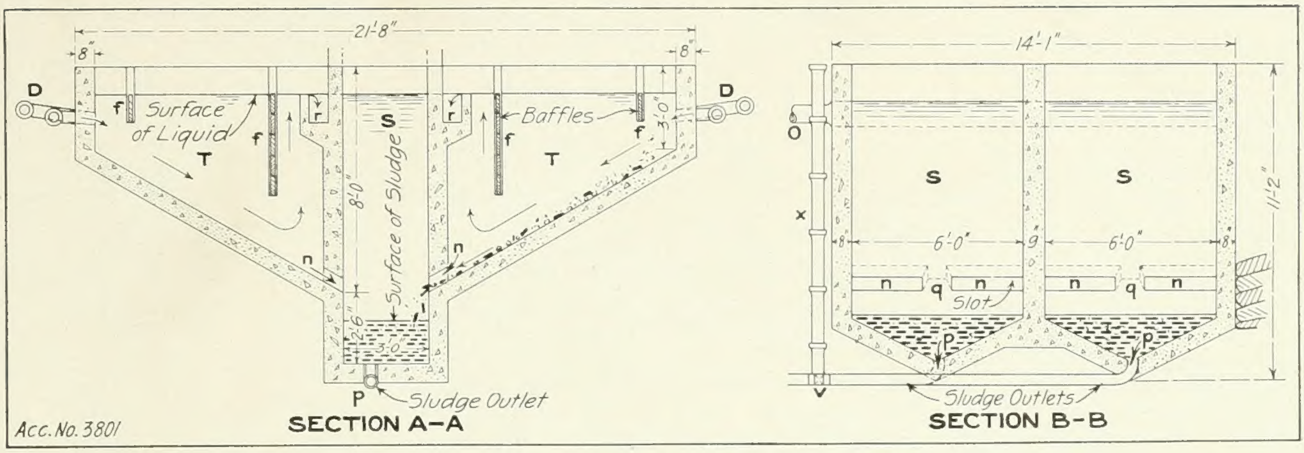

FIG. 132—SEDIMENTATION TANK SECTIONS

tion of the sludge tank, "SS," in which decomposition is in continual progress, from the sedimentation chambers, TT." It is here that the Imhoff system makes a decided step in advance of the old "septic tank," so much in vogue some years ago. There the sludge and sedimentation chambers were in one, the sewage flowing slowly through a single wide rectangular tank, enclosed above, in which the bacterial action on the sludge went on in the presence of the fresh incoming sewage. The outflowing liquid from the septic tank was thus tainted with the products of this sludge decomposition, and on that account was much more liable to become offensive. Imhoff liquid "effluent," discharged still fresh into the receiving lake or stream, is so diluted, and in addition, so widely open to purifying bacterial action after this dilution, that it gives no offense. When not discharged into some body of water, the "effluent" from an Imhoff tank must receive further treatment, by passing it through a "trickling filter," or a "contact bed," where further bacterial action can occur on the liquid, breaking up the organic substances in solution, and reducing them to other chemical compounds which are harmless and inoffensive.

Thus both the solid and the dissolved organic substances which render sewage offensive and dangerous to health are removed in the main, whether in trickling filters or contact beds, or in lakes or running streams, by the action of beneficial bacteria. How little use is made of chemical treatment, by comparison, ap-

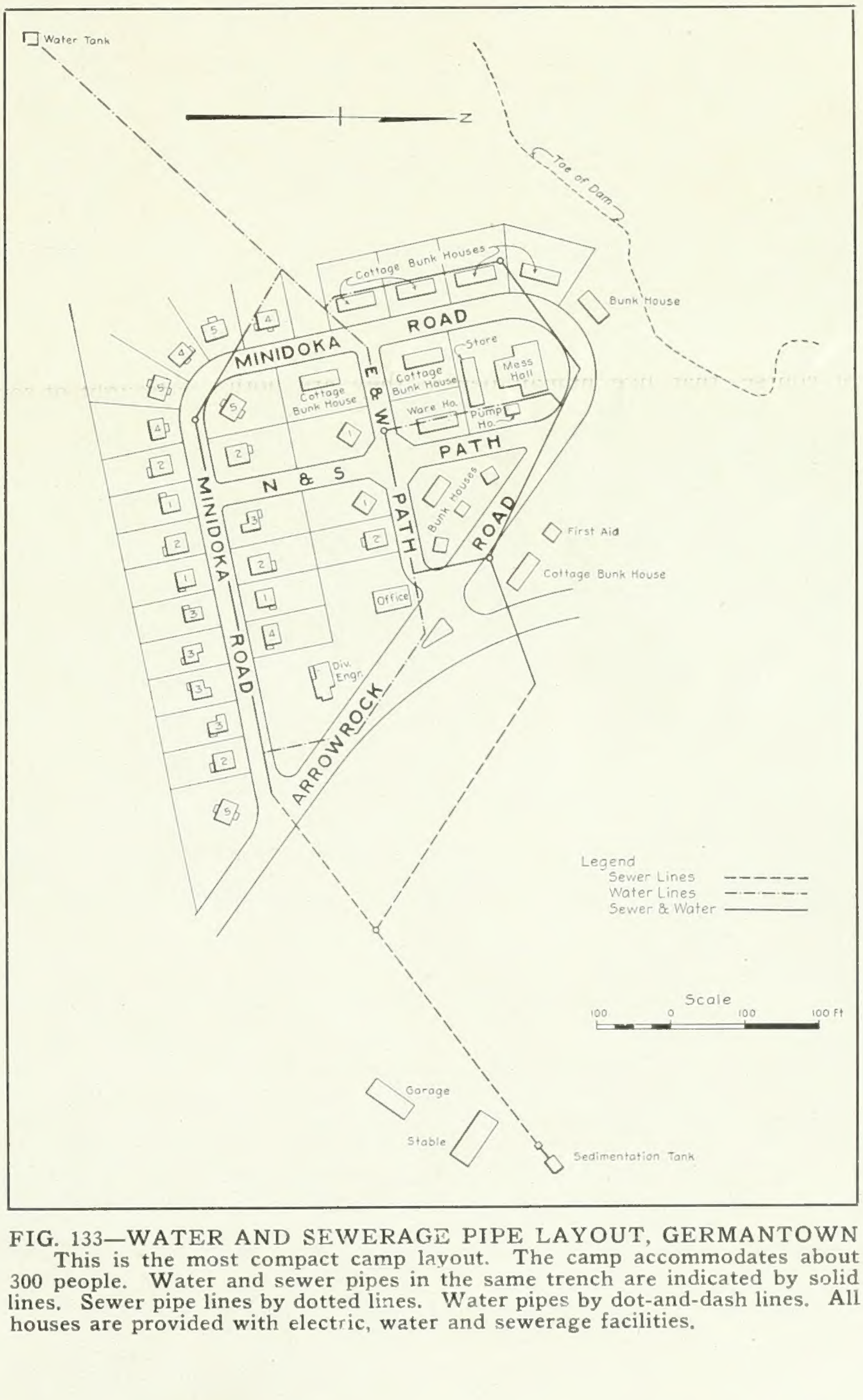

FIG. 133—WATER AND SEWERAGE PIPE LAYOUT, GERMANTOWN

This is the most compact camp layout. The camp accommodates about 300 people. Water and sewer pipes in the same trench are indicated by solid lines. Sewer pipe lines by dotted lines. Water pipes by dot-and-dash lines. All houses are provided with electric, water and sewerage facilities.

pears in the fact that in a modern treatise on sewage disposal, the subject of chemical treatment occupies only two chapters out of twenty. It is an interesting observation that the same microscopic organisms which modern medicine has shown to be in certain species the principal sources of disease, modern sanitation makes use of in other species to smother pestilence and promote health. The thread of good-and-evil runs intertwined through Nature.

The application of a system of sewage treatment to the needs of the Conservancy camps naturally required special adaptation. The camps are small, the two largest built to accommodate a total maximum camp population of about 500. For Conservancy use they would be operated about four years, after which the whole camp plant would have to be disposed of. The sites are all several miles from the nearest town or city, but in all cases except one are near railway or electric railway lines. Under such circumstances it was considered best to so design the camps that they could become permanent villages after the Conservancy work was done. The buildings are inexpensive one or two story structures of the summer cottage type, with water, electric and sewerage service provided.

The sewerage service in such a case must be simple and inexpensive. It must be simple because after the Conservancy work is done, skilled attendance is out of the question. It must be inexpensive obviously, both for Conservancy use and for later recoupment of cost in the sale of the cottages.

At the indoor end, the plumbing is of modern standard design with open plumbing, and sufficient to allow for free use of the village water and proper disposal of all household waste. Connection to the pipe lines in the streets is by 4-inch standard sewer pipe. All equipment, of course, passed the Ohio Board of Health inspection.

The street pipes are six or eight inches in size, and take only the house sewage, storm water from the streets being excluded. To include the latter would have required so large pipes as to make the cost prohibitive. The lines were so located that wherever possible the same trenches would serve both water and sewer pipes, thus saving expense. The sewers were laid on a minimum grade of about 9½ inches in 100 feet, this being the least slope at which the flow is swift enough to keep them clean.

For sewage treatment a standard pattern of Imhoff tank would cost too much, largely on account of the depth necessary, approximating thirty feet. Rock occurring near the ground surface, this would require expensive excavation, since the tanks must be below street sewer level, in order to receive the sewage by gravity flow. It was for this reason that the design indicated in Fig. 132 and described above, was adopted. By locating the greater part of the sludge chamber, between the two sedimentation chambers, instead of below them, a great saving in depth was obtained, while at the same time the sludge decomposition was completely separated from the fresh liquid sewage, as the best results require.

It is interesting, in this connection, to compare the Conservancy tanks with the sedimentation tanks at Orange, Cal. These were originally the old-fashioned septic tanks, and were a nuisance on account of the odor. They were of concrete and were transformed to a modified Imhoff pattern by building inside of them redwood partitions and sloping floors. They were not deepened in the process, however, the depth from the bottom to the surface of the liquid after the change being only 7 feet 9 inches, as against three or more times that dimension in the standard Imhoff design. Nevertheless, the transformation greatly improved the conditions, the sludge after the change being "typical dark-brown Imhoff tank sludge" drying readily after its removal from the tanks. The Conservancy tanks show a depth below the surface of the liquid of 9 feet, 6 inches, as against the 7 feet, 9 inches at Orange, and after being in use more than a year, create no perceptible odor even in the near neighborhood.

The usual discharge of a sewage plant, it has been said, is into some lake or stream, which dilutes it still more, and also gives further opportunity for bacterial action by the micro-organisms which infest practically all natural waters. A lake has certain advantages over a running stream in that the purifying bacterial action takes place more freely in quiet water. On the other hand, the running stream gives much greater and quicker dilution, if of sufficient size. The latter point is, of course, important. Nevertheless, the smallness of the stream flow which will take the sewage of a town, without any preliminary tankage or treatment whatever, and dispose of it without offense, is surprising. Seven cubic feet per second is reckoned ample to take care of a thousand people. A brook seven feet wide and a foot deep, running at an ordinary rate of the Miami River in summer at Main Street bridge, will supply this amount of water. A brook half as large (giving 3½ "second feet"), will be sufficient for such a population in most cases, but is too near the line of possible offense to be desirable.

The point has application in considering the disposal of the sewage effluents at the various Conservancy camps. At Germantown the discharge is into Twin Creek, at Englewood into the Stillwater River, at Lockington into Loramie Creek, at Taylorsville into the Miami, and at Huffman into Mad River. The minimum known flow of these streams, taken in most cases in the summer of 1914, an exceptionally dry season, is shown in the following table. (The flow is in cubic feet per second.)

Minimum Flow of Miami Valley Streams.

Twin Creek	10
Stillwater River (at West Milton)	25
Loramie Creek (In 1918)	9
Miami River (at Tadmor)	70
Mad River (at Springfield)	155
Mad River (at Wilbur Wright Field, 1918	200

The maximum number of men to be provided for at Englewood and Taylorsville, the two largest camps, may be reckoned at 300. With their families, most of them not being married, this might make a total camp population in each of these cases, of 500. At seven cubic feet per second per thousand people, the Stillwater at Englewood (below West Milton), would take care of a population of 3500, seven times the maximum camp population. This, with no sewage treatment whatever. Similarly at Taylorsville, the Miami would take care of 10,000 people; Mad River at Huffman, of 28,000 people; Loramie Creek of 1286, and Twin Creek of 1428. With the known conditions, the danger of creating a nuisance is remote.

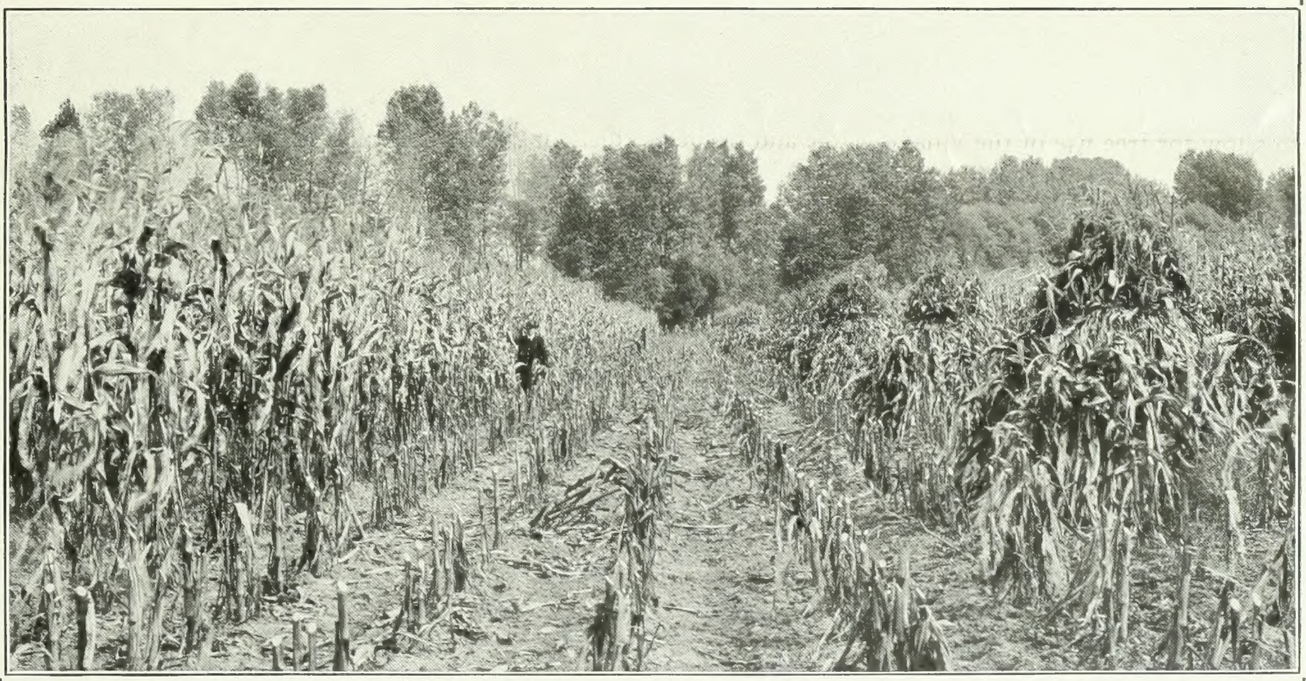

FIG. 134—CONSERVANCY CORN LAND, OCT. 1, 1918.

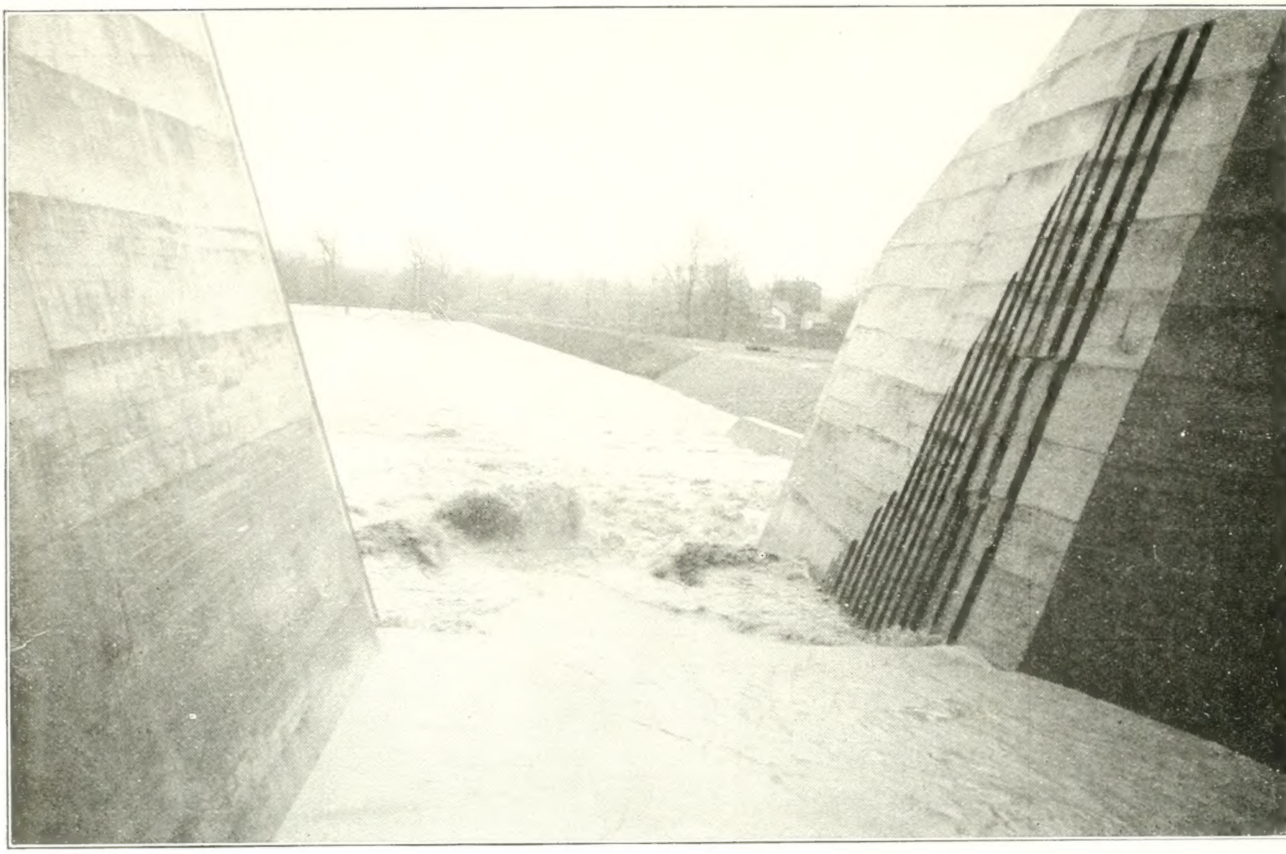

FIG. 135—HYDRAULIC JUMP AT LOCKINGTON DAM, APRIL 20, 1920, LOOKING DOWNSTREAM

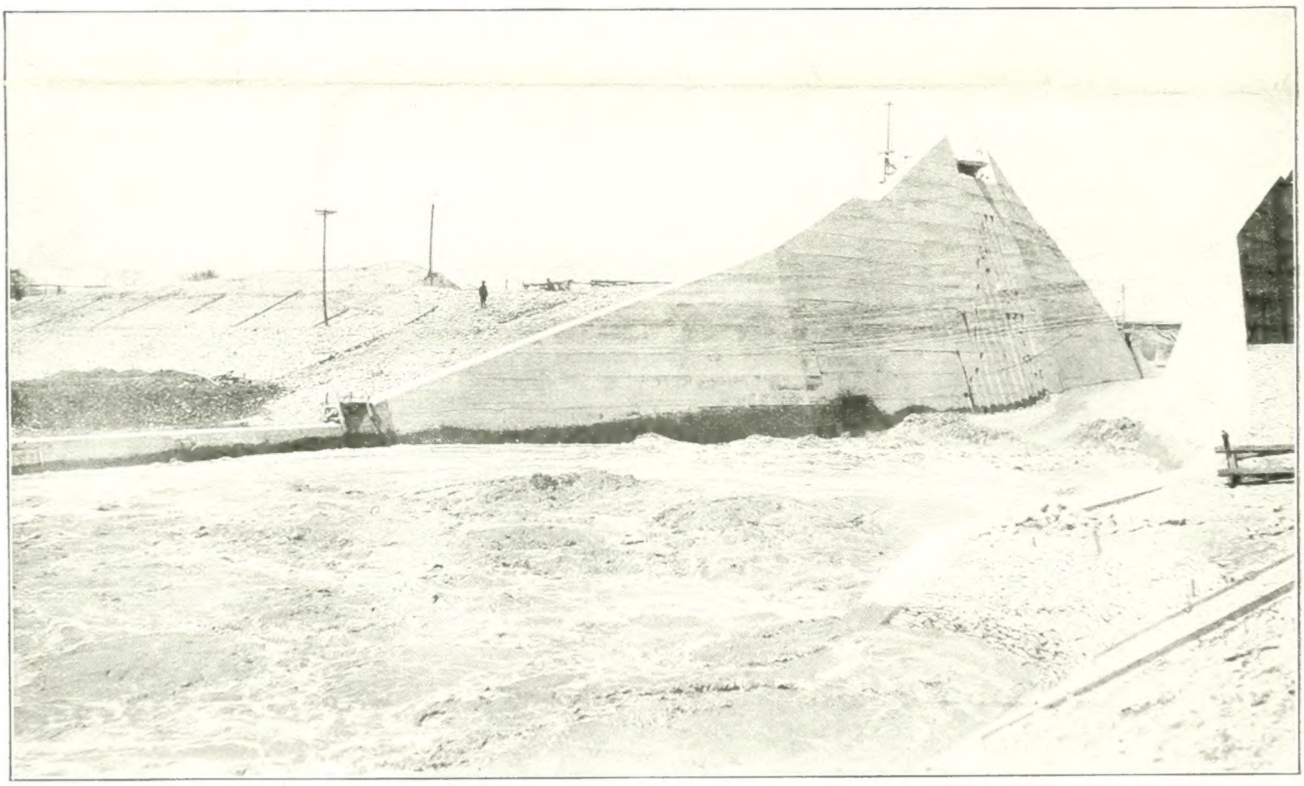

FIG. 136—HYDRAULIC JUMP AT LOCKINGTON DAM, APRIL 20, 1920, LOOKING UPSTREAM

The floor of the outlet works at Lockington is completed to grade throughout; hence the flood (under 10.1 feet head), developed a true hydraulic jump (although a small one), despite the fact that the spillway wall, and the conduits which pierce it, have not been completed. The hydraulic jump at Germantown, shown in Figs. 123 and 124, is not a true "jump," owing to the double depth of the conduits, in their present uncompleted condition, throwing the conduit floor below the true grade. See pages 147 and 148. The pictures showing the condition under a flow due to 10 feet head, some idea may be gained of the condition under maximum flood head (54 feet). To protect the channel below from the destructive energy of the flood water, was one of the most formidable problems of the job.